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VANDENBERG AIR FORCE BASE 'WINDS' COMPARISON STUDY

Wind Towers 300 and 301

James R. Clark, Capt, USAF
Julius A. Jackson, Jr., Capt, USAF

March 1979

REVIEW AND APPROVAL STATEMENT

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Vandenberg AFB "WINDS" Tower 301 will provide the meteorological data to support the launch of the Space Shuttle. The data from Tower 301 have a shorter period of record (POR) than data from Tower 300 which is located a few miles north. For specified wind speed categories, the means and standard deviations of the differences in wind direction, wind speed, and temperature are computed for the towers by season, directional range, day/night, and tower level. Also, the percentage frequency of occurrences

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of temperatures for 15 wind speed categories are calculated. Tower 301 data were correlated with Tower 300 data. The feasibility of creating a bogus POR for Tower 301 using the data from Tower 300 was investigated. The correlation of statistically produced bogus Tower 301 data with the actual Tower 301 data was slightly better than the correlation with the Tower 300 data.

PREFACE

The United States Air Force Environmental Technical Application Center (USAFETAC) prepared this report in answer to a request from the Space and Missile Test Center (SAMTEC), Vandenberg AFB, California, to provide climatological studies of the winds and temperatures at micrometeorological (micromet) Towers 300 and 301 and to study the feasibility of combining these data from the two towers to extend the period of record (POR) of Tower 301 data. In addition to a description of the programs utilized for the climatological summaries, this report gives an extensive discussion of the regression procedures used to create "bogus" data for a tower from the data of the other tower. It also presents graphs of the seasonal comparisons of the data from Towers 300 and 301. First Lieutenant Tamzy J. Cunningham and Major Calvin C. Naegelin were the original project analysts who wrote the program designs for the initial climatological summaries.

If this report is incorporated into another report by any agency, please give USAFETAC proper credit and furnish USAFETAC a copy of the new report if possible. For further information please contact USAFETAC.

TABLE OF CONTENTS

	Page
INTRODUCTION	1
GEOGRAPHY OF SITE	1
DATA PROBLEMS	1
PROGRAM DESCRIPTIONS	7
Wind Speed Versus Temperature (ENBWSVTP)	7
External Tank Icing (ENBWTETI)	7
Wind Tower Comparison (ENBWTCMP)	9
Wind Tower Correlation (ENBWTCOR)	9
ENBWTREM	9
Method of Analysis	9
Regression Analysis	11
Creating Bogus Data	11
RESULTS	11
Comparison of Actual Data	11
Comparison of Bogus Data	13
CONCLUSION	21
Actual Data Comparisons	21
Bogus Data Comparisons	21
REFERENCES	22
APPENDIX A REGRESSION TECHNIQUE	23

LIST OF ILLUSTRATIONS

Figure 1	Prominent Terrain Features, South Vandenberg	6
Figure 2	Example of ENBWSVTP Output	8
Figure 3	Example of ENBWTETI Output	10
Figure 4	Example of ENBWTCOR Output	10
Figure 5	Correlation of U-Component (02-13Z) at Levels 1-5	14
Figure 6	Correlation of U-Component (14-01Z) at Levels 1-5	14
Figure 7	Correlation of V-Component (02-13Z) at Levels 1-5	15
Figure 8	Correlation of V-Component (14-01Z) at Levels 1-5	15
Figure 9	Correlation of Temperature (02-13Z) at Levels 1-5	16
Figure 10	Correlation of Temperature (14-01Z) at Levels 1-5	16
Figure 11	Example of Summer Night Bogus Data	17
Figure 12	Example of Spring Night Bogus Data	18
Figure 13	Example of Summer Day Bogus Data	19
Figure 14	Example of Winter Day Bogus Data	20

LIST OF TABLES

Table 1	Tower 300 Observation Audit	2
Table 2	Tower 301 Observation Audit	4
Table 3	Towers 300 and 301 Observation Frequency	7
Table 4	Correlation Coefficients for Towers 300 and 301	12
Table 5	Comparisons of Correlation Coefficients for Towers 300 and 301	21

VANDENBERG AIR FORCE BASE
'WINDS' COMPARISON STUDY

Wind Towers 300 and 301

INTRODUCTION

The design of the Space Transportation System (STS) launch facility and components of the space shuttle are sensitive to environmental factors. The best climatological summaries of temperature, wind speed, and wind direction are essential for the systems studies and analyses. The data used in this project are from the Weather Information Network and Display Systems (WINDS) at Vandenberg AFB, California. Tower 301, the wind tower supporting the launch site, has a short period of record (POR) compared to that for Tower 300. The purpose of this project was to investigate the existing POR, perform several climatological studies, and determine the feasibility of expanding the POR for Tower 301 using data from Tower 300. Three of the five computer programs developed during this project were designed to answer specific problems for other Space and Missile Test Center (SAMTEC) studies.

GEOGRAPHY OF SITE

The STS launch facility, Space Launch Complex 6 (SLC-6), and micrometeorological (micromet) WINDS Tower 301 (elevation 380 ft) are located in the southern foothills of the Santa Ynez Mountains in South Vandenberg's Punta De La Concepcion area, approximately 1 statute mile east of Point Arguello (Figure 1). Tranquillon Ridge and Cypress Ridge, with peaks ranging from 1000-1600 feet, border the launch facility and Tower 301 on the east, northeast, and southeast. Towards the north, the south, and the west the Santa Ynez foothills slope into the Pacific Ocean. Oceanic wind flow influences the tower's instruments from the east-southeast clockwise to the north-northeast. The wind flow from the remaining quadrant is greatly influenced by the Santa Ynez Mountains.

WINDS Tower 300 (elevation 385 ft) is located approximately 4 statute miles north-northeast of Tower 301 in the northern foothills of the Santa Ynez Mountains. The steep-sided La Honda Canyon, approximately 800 feet deep and 1-1/2 miles wide, is located midway between Towers 300 and 301. To the north and west of Tower 300 the terrain gradually slopes into the ocean; to the northeast the terrain slopes into the low-lying area of Lompoc Terrace. Ridges, ranging in height from 800-1000 feet, border Tower 300 on the south and east. Oceanic wind flow influences the tower from the south-southwestern to the north-northwestern directions. Continental wind flow characterizes the remaining directions.

DATA PROBLEMS

The micromet system is operated and maintained by the Space and Missile Test Center (SAMTEC). The data provide environmental information required for planning, support systems and facilities. The United States Air Force Environmental Technical Applications Center (USAFETAC) collects, stores, retrieves, and processes the micromet data for studies and analyses needed to support customer requirements.

Tables 1 and 2 show the number of observations available at Towers 300 and 301, respectively. Data are collected once per second and averaged over a period of time. The basic time period is 30 minutes. In the audit, an observation is defined as a date/time group. Additional data may be present for one to five levels to include wind speed, wind direction, wind gusts, and temperature.

Table 1. Tower 300 Observation Audit.

BLKSTN	TWR	YRMO	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
723930	300	7106	38	36	38	40	40	40	40	40	40	40	40	38	38	38	38	38	39	38	37	38	40	38	38	36
723930	300	7107	43	43	44	46	46	48	51	59	61	62	60	59	58	59	56	52	49	46	38	40	36	40	43	43
723930	300	7108	23	25	26	26	25	28	30	32	29	28	28	28	29	30	30	26	24	28	28	32	22	19	23	23
723930	300	7109	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0
723930	300	7111	38	37	37	39	44	39	39	41	45	38	39	34	38	36	36	37	38	39	42	44	49	38	39	38
723930	300	7112	59	54	54	53	57	56	56	52	55	54	54	58	58	58	55	53	62	63	59	57	56	53	55	57
723930	300	7201	33	34	34	34	33	34	34	34	34	34	34	34	34	34	34	34	32	30	29	30	30	21	27	30
723930	300	7202	41	40	40	37	37	39	40	40	40	40	38	38	38	38	38	41	45	45	43	44	54	49	47	44
723930	300	7203	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	2
723930	300	7204	50	50	50	45	48	48	48	46	48	48	48	48	48	47	46	46	44	40	44	44	46	46	45	45
723930	300	7205	28	25	24	27	29	32	29	26	25	23	23	22	20	15	18	23	25	28	31	30	30	27	27	29
723930	300	7206	24	28	26	26	24	26	28	26	26	26	26	26	26	24	25	26	25	23	24	28	28	27	24	22
723930	300	7209	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	17	17	25	17	14	19	20	20	20
723930	300	7210	54	54	56	57	56	57	60	60	59	58	57	57	56	56	58	57	53	58	57	58	54	58	55	53
723930	300	7211	43	41	39	39	38	41	42	45	48	48	46	46	46	46	46	46	48	43	45	47	48	47	48	47
723930	300	7212	43	43	43	41	42	42	44	48	46	46	46	46	46	46	46	47	49	46	46	45	48	46	39	40
723930	300	7301	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	4	4	4	4	4	4	4	4
723930	300	7302	40	45	45	44	42	44	41	42	43	44	43	41	41	38	36	41	44	47	44	50	47	46	48	52
723930	300	7303	22	20	20	19	20	22	22	20	19	19	19	19	18	17	17	16	20	19	16	18	17	16	17	18
723930	300	7304	22	22	20	20	21	22	25	26	27	27	26	26	24	24	24	21	16	14	18	20	25	24	20	24
723930	300	7305	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	0
723930	300	7401	37	41	42	43	44	44	45	46	46	46	44	44	44	43	44	42	46	51	48	49	49	48	48	42
723930	300	7404	6	6	6	6	6	6	7	8	8	8	8	8	8	8	9	6	4	4	4	5	6	6	6	6
723930	300	7405	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
723930	300	7406	52	53	51	49	49	53	57	58	58	58	58	58	58	58	59	58	56	53	50	49	52	50	52	55
723930	300	7407	60	60	60	60	60	60	59	60	60	59	57	57	58	58	57	55	52	48	46	49	55	52	52	59
723930	300	7408	56	54	56	57	58	57	57	56	60	59	58	56	57	55	56	54	44	42	42	51	52	54	54	56
723930	300	7409	34	34	37	40	40	40	39	38	36	38	38	38	37	37	36	29	25	23	25	33	27	32	29	33
723930	300	7412	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	6	7	5	6	6	6	6	9
723930	300	7501	38	40	36	28	32	34	32	30	27	28	29	30	25	26	26	26	33	24	22	31	35	28	31	33
723930	300	7502	48	46	41	36	42	41	41	44	43	43	44	44	43	41	38	38	40	37	39	40	36	38	36	34
723930	300	7503	58	58	56	58	56	54	54	55	53	52	52	52	52	50	46	49	46	45	49	54	51	51	55	60
723930	300	7504	52	51	48	50	50	49	48	50	48	46	48	46	46	46	46	46	50	40	49	52	50	50	46	50
723930	300	7506	52	52	52	52	52	52	52	52	52	51	50	50	50	50	50	47	44	35	43	45	44	46	48	49
723930	300	7506	54	52	52	52	54	56	56	56	56	56	56	56	54	54	55	54	54	53	52	49	53	53	55	53
723930	300	7601	49	48	48	46	46	46	46	46	46	46	46	46	46	46	44	44	48	44	44	41	45	45	42	47
723930	300	7602	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2
723930	300	7603	62	63	64	62	62	63	63	62	62	62	62	62	62	61	60	60	57	58	53	58	58	61	57	62
723930	300	7604	55	54	52	52	56	54	56	52	54	54	54	54	54	54	54	54	52	47	48	50	50	49	55	55
723930	300	7605	30	30	30	30	29	28	28	28	28	28	28	28	26	26	26	26	28	26	25	25	28	29	30	28
723930	300	7607	21	21	22	22	22	22	22	22	22	22	22	22	22	22	23	20	18	26	23	24	23	23	24	24
723930	300	7606	62	62	62	62	62	62	62	62	63	62	62	52	62	59	58	55	52	58	62	59	60	58	57	63
723930	300	7609	54	52	52	52	50	50	50	50	50	51	50	50	49	46	50	46	45	40	40	41	41	47	48	51
723930	300	7610	6	6	6	6	6	6	6	6	4	4	4	4	4	4	4	7	5	4	4	7	6	4	6	6
723930	300	7611	37	38	38	38	38	38	38	36	36	36	36	36	36	36	36	36	35	28	26	29	37	36	37	37
723930	300	7612	50	50	50	50	50	51	50	51	49	50	50	50	50	50	50	52	51	46	52	52	52	53	52	51
723930	300	7701	58	57	56	55	55	50	50	50	50	50	50	49	50	51	48	50	47	33	33	42	45	45	47	50
723930	300	7702	38	38	37	38	38	-38	38	38	38	38	36	36	36	36	36	36	28	20	24	24	28	28	25	35
723930	300	7703	12	12	12	11	12	12	12	12	12	12	12	12	12	12	12	12	11	10	10	10	8	10	12	12

Table 1. Tower 300 Observation Audit (Cont'd).

BLKSTN	TWR	YRMO	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
723930	300	7704	49	50	50	50	50	51	52	52	51	50	50	50	50	50	48	51	46	37	38	35	37	37	36	39
723930	300	7705	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
723930	300	7706	58	58	59	59	59	58	58	58	58	58	58	58	58	56	56	56	49	48	53	55	49	50	54	56
723930	300	7707	54	53	53	54	56	56	56	56	56	56	56	54	54	54	55	53	51	50	52	52	49	51	54	51
723930	300	7708	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	6	6	6	6	6	6
723930	300	7709	60	60	59	57	56	58	60	60	60	60	60	60	60	60	60	59	51	52	58	59	58	52	58	60
723930	300	7710	56	56	56	54	54	55	56	56	56	56	56	56	56	56	56	52	51	56	56	60	54	52	56	58
723930	300	7711	52	52	52	50	50	50	50	50	50	50	48	48	48	48	44	49	51	52	51	52	50	52	50	48
723930	300	7712	47	44	42	43	44	43	40	40	40	38	38	38	38	38	38	42	41	41	38	41	42	44	42	45
723930	300	7801	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
723930	300	7802	48	48	48	47	46	46	46	48	48	46	46	46	46	44	42	45	43	35	39	38	44	47	49	50
723930	300	7803	51	50	50	52	52	52	52	52	52	51	50	50	50	50	50	54	53	54	51	51	53	56	56	54
723930	300	7804	56	56	58	58	58	58	58	58	58	58	58	58	58	58	58	59	60	53	55	51	52	51	50	54
723930	300	7805	48	46	46	46	46	46	46	46	46	46	46	44	44	42	39	37	31	32	31	33	35	32	39	45

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Table 2. Tower 301 Observation Audit.

BLKSTN	TWR	YRMO	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
723930	301	6602	17	19	17	18	17	18	17	16	16	17	16	16	17	17	18	19	20	20	19	18	19	19	19	18
723930	301	6603	24	25	25	24	24	24	24	24	24	23	23	22	25	24	23	22	23	24	25	24	24	22	23	23
723930	301	6604	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
723930	301	6605	30	30	30	30	30	30	30	30	30	29	29	30	30	30	30	30	30	30	29	29	29	29	29	29
723930	301	6606	27	26	26	26	27	27	27	27	27	27	28	27	28	27	28	28	28	28	28	27	27	27	27	27
723930	301	6607	27	27	27	27	26	26	26	26	26	26	27	27	27	27	27	27	27	27	27	27	27	27	27	27
723930	301	6608	31	31	31	31	31	31	31	30	30	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
723930	301	6609	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	30	30	30	30	29	29	29	29	29
723930	301	6610	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
723930	301	6611	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
723930	301	6612	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
723930	301	6701	30	30	30	30	30	30	30	30	30	30	29	29	30	30	30	31	31	31	30	30	30	30	30	30
723930	301	6702	28	28	28	28	28	28	28	28	28	26	28	28	29	28	28	28	28	28	28	28	28	28	28	28
723930	301	6703	30	30	30	30	30	30	30	30	30	30	30	31	31	31	31	30	30	30	30	30	30	30	30	30
723930	301	6704	30	30	29	29	29	29	29	29	29	29	29	29	29	29	30	30	30	30	30	30	30	30	30	30
723930	301	6705	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
723930	301	6706	47	47	46	46	44	44	44	44	44	45	46	48	49	48	48	50	50	50	50	50	49	49	49	49
723930	301	6707	51	51	50	51	51	51	51	51	49	52	53	54	53	52	50	50	50	50	50	50	50	50	50	50
723930	301	6708	49	50	49	48	47	48	48	47	49	50	50	52	51	51	54	56	56	56	56	56	55	53	53	52
723930	301	6709	45	43	42	42	41	40	41	41	41	43	43	41	41	42	44	45	45	45	45	45	45	45	45	45
723930	301	6710	56	56	56	56	56	56	55	55	55	56	57	57	55	56	56	54	54	57	57	56	57	57	57	55
723930	301	6711	54	54	54	54	54	54	54	55	55	54	55	54	55	52	51	51	54	53	53	53	53	53	52	53
723930	301	6712	51	51	51	51	51	49	49	48	48	47	47	46	47	48	48	50	50	53	53	53	53	53	52	51
723930	301	6801	52	52	52	52	52	52	52	52	52	52	49	47	50	49	51	53	51	53	54	54	53	53	52	52
723930	301	6802	51	51	52	50	49	49	49	49	48	49	48	46	46	49	48	52	53	51	53	53	52	52	52	52
723930	301	6803	44	44	44	44	44	44	44	40	40	37	39	43	46	50	50	50	50	49	49	46	47	46	45	45
723930	301	6804	54	53	53	53	53	53	54	52	53	53	52	53	53	53	53	50	53	53	53	53	53	53	53	53
723930	301	6805	34	34	34	34	34	34	34	34	34	34	34	34	33	33	33	33	33	33	33	33	33	33	33	33
723930	301	6806	30	30	30	30	30	29	29	29	29	29	29	29	29	30	30	30	30	30	30	30	30	30	30	30
723930	301	6807	31	31	31	31	31	31	31	31	31	30	31	31	31	31	31	31	31	31	31	21	31	31	31	31
723930	301	6808	31	31	31	31	31	31	31	31	31	31	21	31	31	31	31	31	31	31	31	31	31	31	31	31
723930	301	6809	29	29	29	29	29	29	28	28	28	28	28	29	29	30	30	30	30	30	30	20	30	30	30	29
723930	301	6810	31	31	31	31	31	31	31	31	31	31	31	31	31	31	32	32	32	31	31	32	32	32	32	32
723930	301	6811	30	30	30	30	30	30	30	30	30	30	30	30	30	20	30	29	30	30	30	30	30	30	30	30
723930	301	6812	31	31	31	31	31	31	31	31	31	31	31	31	31	29	30	30	31	31	31	31	31	31	31	31
723930	301	7501	2	0	0	0	5	7	6	6	5	2	2	2	3	4	4	4	6	3	7	10	12	11	9	5
723930	301	7502	48	46	41	36	42	41	41	44	43	43	44	44	43	41	38	38	40	37	39	40	36	38	36	34
723930	301	7503	30	31	30	32	30	28	28	29	27	26	26	26	26	25	26	25	26	23	29	29	30	28	31	32
723930	301	7504	50	49	46	48	48	47	46	48	46	46	46	44	44	44	44	44	48	39	48	51	50	48	45	47
723930	301	7506	52	52	52	52	52	52	52	52	52	51	50	50	50	50	50	47	44	39	43	45	44	46	48	49
723930	301	7508	54	52	52	52	54	56	56	56	56	56	56	56	54	54	55	54	54	53	52	49	53	53	54	53
723930	301	7601	43	42	42	40	40	43	40	40	40	40	40	40	40	40	38	38	42	40	40	37	41	41	37	41
723930	301	7602	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	[illegible]	2
723930	301	7603	62	63	64	62	62	63	63	62	62	62	62	62	62	61	60	60	58	59	56	58	58	61	57	62
723930	301	7604	55	54	52	52	56	54	56	52	54	54	54	54	54	54	54	54	52	47	48	50	50	49	55	55
723930	301	7605	30	30	30	30	29	28	28	28	28	28	28	28	26	26	26	26	28	26	25	25	28	29	30	28
723930	301	7607	21	21	22	22	22	22	22	22	22	22	22	22	22	22	23	20	18	26	23	24	23	23	24	24
723930	301	7608	62	62	62	62	62	62	62	62	63	62	62	62	62	59	58	55	52	58	62	59	60	58	57	63
723930	301	7609	54	52	52	52	50	50	50	50	50	51	50	50	49	46	50	46	45	40	40	41	41	47	48	51

Table 2. Tower 301 Observation Audit (Cont'd).

BLKSTN	TWR	YRMO	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
723930	301	7610	6	6	6	6	6	6	6	6	4	6	6	6	4	6	4	7	5	4	6	7	6	4	6	6
723930	301	7611	38	38	38	38	37	38	37	36	36	36	36	36	36	36	36	36	35	28	26	29	37	36	37	37
723930	301	7612	50	50	50	50	50	51	50	51	49	50	50	50	50	50	50	52	51	46	52	52	52	53	52	51
723930	301	7701	22	21	20	20	21	18	18	18	18	18	18	18	18	19	19	18	20	15	15	17	17	19	20	30
723930	301	7702	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	28	19	23	24	28	28	25	35
723930	301	7703	12	12	12	11	12	12	12	12	12	12	12	12	12	12	12	12	11	10	10	9	8	10	12	12
723930	301	7704	49	50	50	50	50	51	52	52	51	50	50	50	50	50	48	51	46	37	38	35	37	37	36	39
723930	301	7705	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
723930	301	7706	58	58	59	59	59	58	58	58	58	58	58	58	58	56	56	56	49	48	53	55	49	50	54	56
723930	301	7707	54	53	53	54	56	56	56	56	56	56	56	54	54	54	55	53	51	50	52	52	49	51	54	51
723930	301	7708	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	6	6	6	6	6	6
723930	301	7709	60	60	59	57	56	58	60	60	60	60	60	60	60	60	60	59	51	52	58	59	58	52	58	60
723930	301	7710	56	56	56	54	54	55	56	56	56	56	56	56	56	56	56	52	[illegible]	56	56	60	54	52	56	58
723930	301	7711	52	52	52	50	50	50	50	50	50	50	48	48	48	48	44	49	51	52	51	52	50	52	50	48
723930	301	7712	47	44	42	43	44	43	40	40	40	38	38	38	36	38	38	42	41	41	38	41	42	44	42	45
723930	301	7801	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
723930	301	7802	48	48	48	47	46	46	46	48	48	46	46	46	46	44	42	45	43	35	39	38	44	47	49	50
723930	301	7803	51	50	50	52	52	52	52	52	52	51	50	50	50	50	50	54	53	54	51	51	53	56	56	54
723930	301	7804	56	56	58	56	58	58	58	58	58	58	58	58	58	58	55	59	60	53	55	51	52	5	50	54
723930	301	7805	48	46	46	46	46	46	46	46	46	46	46	44	44	42	39	37	31	32	33	33	15	32	39	49

JOB COMPLETED. 0 TAPE ERRORS 60105 OBS EXTRACTED

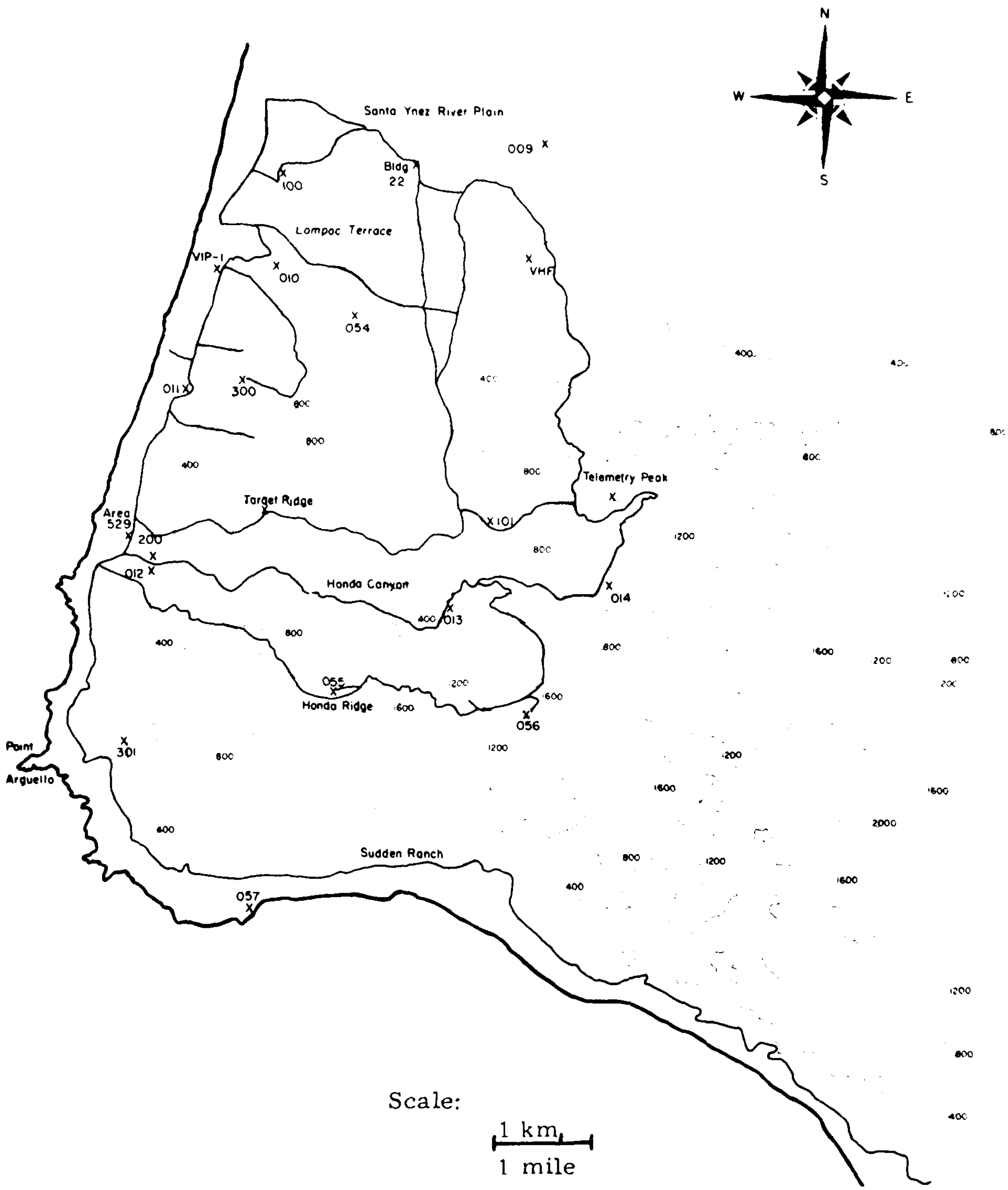

Figure 1. Prominent Terrain Features, South Vandenberg (Hinds and Nickola, 1968).

Tower 300 data are available for the period June 1971 to May 1978. Two observations per hour are available except for a short period from 1 June 1971 to 22 June 1971 when 5- and 15-minute observations were taken. May 1978 was the last month used in this study.

Tower 301 data from February 1966 to December 1968 were not used in this study due to the lack of temperature information. No data were available from 1 June [illegible] until 23 January 1975. Data recorded from 23 January 1975 to 12 April 1975 contain only date/time groups. After April 1975 an observational count in the 60s indicates the maximum data available. From April 1975 through May 1978 miscellaneous months are missing or have low observation counts. May 1978 was the termination point for data used in this project. Table 3 gives a breakdown of the frequency of observations at the two towers.

Table 3. Towers 300 and 301 Observation Frequency.

TOWER	DATE	FREQUENCY
300	14 Jun 71-22 Jun 71	Hourly, 5 min
	23 Jun 71-31 May 78	Hourly, Hour + 30 min
301	02 Feb 66-31 May 67	Hourly
	01 Jun 67-03 May 68	Hourly, Hour + 10 min
	04 May 68-31 Dec 68	Hourly
	23 Jan 75-31 May 78	Hourly, Hour + 30 min

By studying the audit one can see that although there is a lengthy POR for both towers, the usable data are limited. The POR is further decreased by some observations containing only a date/time group with no accompanying meteorological data or few levels. This short POR is the primary reason for attempting to supplement Tower 301 data with data from Tower 300.

PROGRAM DESCRIPTIONS

Five computer programs were developed: ENBWSVTP, ENBWTETI, ENBWTCMP, ENBWTCOR, and ENBWTREM. The first two programs produce specific climatological data summaries. The third program reformats the data for use in the fourth and fifth programs, which also produce specific climatological data summaries. The first four programs will be discussed in this section. Due to the complexity and scope of the fifth program, it will be examined in a separate section.

The climatological studies were done for five levels (12, 54, 102, 204, and 300 ft), the four seasons, and the four wind-directional sectors (030°-119°, 120°-209°, 210°-299°, 300°-029°). Each summary except for the ENBWSVTP output was computed for daytime (1400-0100Z) and nighttime (0200-1300Z). The ENBWSVTP output is summarized in three-hour blocks. In addition to the standard paper copies, microfiche copies are available. Due to the volume of data involved, only examples are shown in this report.

Wind Speed Versus Temperature (ENBWSVTP)

This program assists in planning the design of support facilities, systems, and procedures to be used in launching the space shuttle. The program calculates percentage frequency of occurrence of 15 wind speed and 30 temperature categories. Statistics were computed for each of the five levels for Towers 300 and 301. An example of the annual table for all hours and wind directions for Tower 301 is shown in Figure 2. The format of the seasonal table is identical. The POR for Tower 300 was 14 June 1971-30 September 1977 and for Tower 301, 13 February 1975-21 November 1977.

External Tank Icing (ENBWTETI)

The formation of frost or ice on the space shuttle's external fuel tank is a critical problem. The data from this program can be used to determine the frequency and severity of meteorological conditions favorable to icing at Space Launch Complex (SLC-6).

FRAME J12

UNITED STATES AIR FORCE ENVIRONMENTAL APPLICATIONS CENTER, SCOTT AFB IL 62225 -- ENBWSVTP - 1.0 PREPARED: 8 APR 78

VANDENBURG WIND TOWER 301

TOWER NUMBER: 301
LEVEL: 4

ANNUAL

WIND DIRECTION: ALL
HOURS: ALL

WIND SPEED VERSUS TEMPERATURE

PERCENTAGE FREQUENCY OF OCCURRENCE

(FROM 30-MINUTE MEANS)

TEMPERATURE (DEG F)	WIND SPEED (KTS) >=56	>=50	>=44	>=38	>=32	>=26	>=23	>=20	>=17	>=14	>=11	>=8	>=5	>=2	>=0
>=100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>= 95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>= 90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>= 85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>= 80	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
>= 75	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2
>= 70	0	0	0	0	0	0	0	0	0	1	1	2	4	6	7
>= 65	0	0	0	0	0	0	0	1	1	3	5	7	9	14	15
>= 60	0	0	0	0	0	1	1	3	6	10	15	20	26	34	36
>= 58	0	0	0	0	0	1	2	4	9	15	21	28	36	46	48
>= 56	0	0	0	0	0	1	2	5	12	20	27	37	47	60	62
>= 54	0	0	0	0	0	1	3	8	17	27	37	48	60	75	78
>= 52	0	0	0	0	0	2	4	9	20	32	43	55	68	85	88
>= 50	0	0	0	0	1	2	5	11	23	36	48	61	74	91	95
>= 48	0	0	0	0	1	2	5	12	24	37	49	63	77	95	98
>= 46	0	0	0	0	1	2	5	12	24	38	50	63	77	96	99
>= 44	0	0	0	0	1	2	5	12	24	38	50	63	77	96	100
>= 42	0	0	0	0	1	2	5	12	24	38	50	63	77	97	100
>= 40	0	0	0	0	1	2	5	12	24	38	50	63	77	97	100
>= 38	0	0	0	0	1	2	5	12	24	38	50	63	77	97	100
>= 36	0	0	0	0	1	2	5	12	24	38	50	63	77	97	100
>= 34	0	0	0	0	1	2	5	12	24	38	50	63	77	97	100
>= 32	0	0	0	0	1	2	5	12	24	38	50	63	77	97	100
>= 30	0	0	0	0	1	2	5	12	24	38	50	63	77	97	100
>= 28	0	0	0	0	1	2	5	12	24	38	50	63	77	97	100
>= 26	0	0	0	0	1	2	5	12	24	38	50	63	77	97	100
>= 24	0	0	0	0	1	2	5	12	24	38	50	63	77	97	100
>= 22	0	0	0	0	1	2	5	12	24	38	50	63	77	97	100
>= 20	0	0	0	0	1	2	5	12	24	38	50	63	77	97	100
>= 0	0	0	0	0	1	2	5	12	24	38	50	63	77	97	100

TOTAL OBS 11321

POR: 13 FEB 75 - 21 NOV 77

Figure 2. Example of ENBWSVTP Output.

The program computes statistical data for wind speed, wind direction, and temperature using data for a single tower. Two observations for the same level, separated in time by the user-specified interval, are located, and the differences in wind speed, wind direction, and temperature for the specified time interval are computed. The difference is defined as the later value minus the earlier value. The mean and the standard deviation of the differences for all three parameters are calculated for the respective 11 speed categories. The values are summarized for each level, wind directional sector, and season. An all-directional and seasonal summary is also included. Figure 3 is an example of the ENBWTETI output. Only Tower 301 data for 23 January 1975-24 May 1978 were used.

Wind Tower Comparison (ENBWTCMP)

The third program provides an intermediate step to merge the data from Towers 300 and 301 together on a tape. This output is the input for the comparison and regression analyses. The program reads the POR tapes from Towers 300 and 301 to obtain concurrent observations within the desired hour spans. If any data are missing, the entire observation is discarded. The output is recorded on two different tapes depending upon which hour span the observation falls into. The final output tape contains concurrent observations of wind direction, wind speed, temperature, and temperature differences for five levels at each tower.

Wind Tower Correlation (ENBWTCOR)

This program compares the data from Towers 300 and 301. Using the output from the ENBWTCMP program, the program compares wind direction, wind speed, and temperature from a data-rich tower (300) and a relatively data-poor tower (301). Means and standard deviations for differences in wind direction, wind speed, and temperature are computed and categorized by 11 specified wind speeds. The difference is defined as the Tower 301 values minus the Tower 300 value. The format of the output table is similar to that of the ENBWTETI data (Figure 4). The tables are presented seasonally by wind directional sector and tower level. Also included is an annual and all-directional sector table.

ENBWTREM

This section describes the creation of a new POR of winds and temperature data for micromet Tower 301. Due to the limited amount of data from Tower 301, the data from Tower 300 is used to create new "bogus" data for Tower 301.

Method of Analysis

Initially, data from the two towers were compared and concurrent observations extracted from each wind tower. A statistical regression analysis of these comparisons yielded regression coefficients which were utilized to create bogus data for the data-poor tower from the data-rich tower data.

The data were divided into day and night observations. The wind was broken down into U- and V-components for this analysis. The regression analysis compared the five levels of the U-component, V-component, and temperature of Tower 301 against the five levels of Tower 300. One component from one level of Tower 301 was compared against the three components of Tower 300 to find the best correlation (i.e., the U-component of level one (12 ft) of Tower 301 was compared against the five levels of the U-component, five levels of the V-component, and the five levels of the temperature component of Tower 300).

A comparison was made between the actual data of the two towers before the bogus data program was implemented. Besides being examined for annual day and night observations, the data were also analyzed for seasonal (spring, summer, autumn, winter) categories.

FRAME 0[illegible]
UNITED STATES AIR FORCE ENVIRONMENTAL TECHNICAL APPLICATIONS CENTER, SCOTT AFB, IL 62225 ** ENBWTETI - [illegible] ** PREPARED [illegible] AUG 78

VANDENBERG "WINDS" COMPARISON
TOWER: 301
CONSECUTIVE [illegible]-MINUTE MEANS

PERIOD OF RECORD [illegible]

SEASON : ANNUAL
LEVEL : ALL FT
WND DIR : ALL

SPEED IN KNOTS	DIRECTION DIFFERENCES (DEGREES) MEAN	STND DEV	# OF OBS	SPEED DIFFERENCES (KNOTS) MEAN	STND DEV	# OF OBS	TEMPERATURE DIFFERENCES (FAHRENHEIT) MEAN	STND DEV	# OF OBS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.45	52687	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	66266	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.93	23758	[illegible]	1.29	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3599	[illegible]	1.34	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.05	10556
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.89	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.96	22692	-0.0	1.66	21589
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.09	21774	-0.0	1.39	20694
[illegible]	[illegible]	9.84	[illegible]	[illegible]	[illegible]	16176	-0.0	1.35	15366
[illegible]	[illegible]	[illegible]	7587	[illegible]	[illegible]	7586	[illegible]	[illegible]	6996
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3599	[illegible]	1.34	[illegible]

*** # OF OBS NUMBER OF OBSERVATION PAIRS ***

Figure 3. Example of ENBWTETI Output.

FRAME 010
UNITED STATES AIR FORCE ENVIRONMENTAL TECHNICAL APPLICATIONS CENTER, SCOTT AFB, IL 62225 - ENBWTCOR - 1.0 - PREPARED: 27 SEP 78

VANDENBERG "WINDS" COMPARISON
TOWER 300 VS TOWER 301

PERIOD OF RECORD: 750621-780521

QUARTER: ANNUAL
LEVEL: ALL FEET
WIND DIRECTION: ALL

SPEED (KNOTS) (TWR 301)	NUMBER OF OBSERVATIONS	DIRECTION DIFFERENCES AVERAGE	STANDARD DEVIATIONS	SPEED DIFFERENCES AVERAGE	STANDARD DEVIATIONS	TEMPERATURE DIFFERENCES AVERAGE	STANDARD DEVIATIONS
0-7	9367	7.2	62.03	0.1	3.63	0.0	3.72
8-15	11631	10.2	41.02	6.7	3.65	-0.2	2.86
15-23	6055	10.3	28.65	7.5	4.23	0.1	3.82
>=24	602	9.3	23.50	9.4	7.21	0.2	3.67
0-3	1152	5.8	74.11	-1.8	3.78	0.2	4.82
4-7	4391	6.6	55.10	1.1	2.85	-0.1	3.01
8-11	6659	10.1	44.49	3.4	3.22	-0.2	2.88
12-15	4972	10.3	30.01	6.0	3.26	-0.1	2.79
16-19	3005	10.5	29.02	7.6	3.94	0.0	3.20
20-23	1040	9.5	26.72	7.8	4.96	0.3	3.21
>=24	602	9.3	23.30	8.4	7.21	0.2	3.67

Figure 4. Example of ENBWTCOR Output.

Regression Analysis

The statistical analysis used in this study was a step-wise multiple regression. Step-wise multiple regression is a statistical technique for analyzing a relationship between a dependent variable and a set of independent variables (best predictors) in the order of their importance. The method used to decide the order of the predictors is based upon the reduction of the sum of squares of the dependent variable. From this analysis, the regression coefficients from the best predictors were used in the creation of the bogus data. The Appendix to this report provides details of the regression analysis technique.

Creating Bogus Data

The bogus data were created by using the regression coefficients with the formulas

$$U(j) = UA(j) + \sum_{i=1}^{5} [UB(j,i)\ U(i) + UC(j,i)\ V(i)] + UD(j)\ TD$$

$$V(j) = VA(j) + \sum_{i=1}^{5} [VB(j,i)\ U(i) + VC(j,i)\ V(i)] + VD(j)\ TD$$

$$T(j) = TA(j) + \sum_{i=1}^{5} [TB(j,i)\ U(i) + TC(j,i)\ V(i)] + \sum_{i=1}^{5} [F(j,i)\ T(i)]$$

where U = U-component,

V = V-component,

T = temperature,

TD = temperature difference between level 5 and level 1,

j = the level being computed, in turn, from 1 through 5,

i = the level of the second tower for which the data are available, also for levels 1 through 5,

A, B, C, D and F are the regression coefficients.

The ENBWTREM program uses the above formulas to create a bogus POR. This program uses the regression coefficients and data values from the data-rich tower and computes new values for times when no observations are available for the data- poor tower. If just the data-poor tower had an observation or if both towers had observations at the same time, the data-poor observations were used unchanged. If just the data-rich tower had an observation, values were computed for the data-poor tower using the corresponding date-time group from the data-rich tower observation.

RESULTS

Comparison of Actual Data

The results of the analysis are shown in Table 4. The table contains the five levels of each component. The left column represents Tower 301 components and levels. The Tower 300 component that best correlates with the corresponding Tower 301 component and level are presented for day and night, each season, and annual summary.

Table 4. Correlation Coefficients for Towers 300 and 301.

TOWER 301 COMPONENT AND LEVEL	DEC-FEB 02-13Z COEFF	TOWER 300 COMPONENT AND LEVEL	DEC-FEB 14-01Z COEFF	TOWER 300 COMPONENT AND LEVEL	MAR-MAY 02-01Z COEFF	TOWER 300 COMPONENT AND LEVEL	MAR-MAY 14-01Z COEFF	TOWER 300 COMPONENT AND LEVEL	JUN-AUG 02-13Z COEFF	TOWER 300 COMPONENT AND LEVEL
U1	0.510	U1	0.670	U2	0.544	U3	0.611	U2	0.459	U1
U2	0.524	U1	0.682	U5	0.709	U1	0.798	U1	0.486	U2
U3	0.301	U5	0.469	U4	0.436	U1	0.715	U5	0.544	V2
U4	0.297	U5	0.368	U5	0.593	U4	0.648	U4	0.776	V5
U5	0.590	U1	0.751	U5	0.753	U2	0.821	U5	0.157	V2
V1	0.828	V3	0.759	V5	0.869	V1	0.869	V5	0.872	V5
V2	0.794	V5	0.736	V5	0.874	V1	0.885	V3	0.888	V5
V3	0.817	V5	0.750	V5	0.894	V1	0.897	V1	0.895	V5
V4	0.800	V2	0.727	V5	0.769	V5	0.783	V5	0.894	V3
V5	0.849	V5	0.800	V5	0.896	V1	0.895	V5	0.913	V5
T1	0.855	T1	0.924	T1	0.833	T1	0.765	T1	0.871	T1
T2	0.959	T3	0.933	T3	0.827	T3	0.614	T3	0.973	T2
T3	0.960	T3	0.944	T4	0.842	T3	0.606	T2	0.972	T3
T4	0.968	T5	0.945	T5	0.599	T5	0.483	T1	0.912	T3
T5	0.962	T5	0.939	T5	0.810	T5	0.553	T3	0.720	T5

TOWER 301 COMPONENT AND LEVEL	JUN-AUG 14-01Z COEFF	TOWER 300 COMPONENT AND LEVEL	SEP-NOV 02-13Z COEFF	TOWER 300 COMPONENT AND LEVEL	SEP-NOV 14-01Z COEFF	TOWER 300 COMPONENT AND LEVEL	ANNUAL 02-13Z COEFF	TOWER 300 COMPONENT AND LEVEL	ANNUAL 14-01Z COEFF	TOWER 300 COMPONENT AND LEVEL
U1	0.744	U1	0.436	V1	0.643	U2	0.453	U2	0.634	U5
U2	0.637	U1	0.434	V4	0.672	U1	0.495	U1	0.683	U5
U3	0.667	U2	0.384	V4	0.444	U4	0.370	U4	0.503	U5
U4	0.785	U4	0.513	V4	0.657	U5	0.544	U4	0.651	U5
U5	0.302	U3	0.592	V5	0.731	U5	0.562	U5	0.683	U5
V1	0.901	V5	0.779	V2	0.770	V5	0.802	V1	0.807	V3
V2	0.849	V3	0.813	V2	0.809	V5	0.818	V3	0.813	V5
V3	0.908	V5	0.783	V3	0.782	V5	0.821	V3	0.824	V5
V4	0.880	V5	0.831	V5	0.849	V5	0.781	V3	0.806	V5
V5	0.911	V6	0.856	V5	0.851	V5	0.859	V5	0.862	V5
T1	0.823	T1	0.877	T1	0.883	T1	0.859	T1	0.888	T1
T2	0.896	T4	0.937	T2	0.915	T3	0.946	T2	0.871	T3
T3	0.898	T4	0.945	T3	0.920	T3	0.950	T3	0.873	T3
T4	0.865	T4	0.924	T4	0.916	T4	0.849	T5	0.767	T4
T5	0.764	T4	0.927	T5	0.917	T5	0.923	T5	0.827	T4

This table shows that the V-component and temperature correlate better than the U-component. Some of the seasons correlated better than others, and the day correlations were higher than the night correlations. At certain levels there is not a one-to-one correspondence. In some of the U-component comparisons, the V-component from Tower 300 correlated better than the U-component at certain levels. The results of this analysis are also plotted (by component and by time of day) in Figures 5-10.

U-Component (0200-1300Z, Figure 5). The first and second levels correlate fairly well, while there is a large difference in levels 3, 4, and 5. The winter, spring, and fall pattern at levels 3 and 4 do not have very high correlations, while the summer correlations are highest at these levels. At level 5, all seasons correlate fairly well, except for summer.

U-Component (1400-0100Z, Figure 6). These graphs are little changed from the night graphs (Figure 5), but exhibit an overall higher correlation. The summer pattern still has the best correlation, and the winter the worst, except for the first two levels.

V-Component (0200-1300Z, Figure 7, and 1400-0100Z, Figure 8). The pattern of the V-component curves varies little between these two figures. Overall, the summer V-component exhibits the highest correlation.

Temperature (0200-1300Z, Figure 9, and 1400-0100Z, Figure 10). The spring temperature curves show the only significant variation. The best temperature correlations in the spring are at night.

Comparison of Bogus Data

Correlation Analysis. After creating the bogus data, correlation analyses were run on the bogus and actual tower data. The results of these analyses are in Table 5. The first two columns are the correlation coefficients for the actual Towers 300 and 301 data before creating the bogus data. The next two columns are the comparisons of the actual Tower 301 data versus the bogus 301 data created by forcing the actual Tower 301 data through the statistical analyses.

There is only a slight difference between the correlations of the actual Towers 301 and 300 data and the Tower 301 actual (before) and bogus (after) data. The bogus data have a slightly higher correlation, especially in the lower levels of the U-component in the night observations. The day observations are also a little higher. The largest difference is in the night U-component.

Examples of Bogus Data. Figures 11-14 are examples of the bogus data. The bogus observations have no gust, integration period (IP), or reliability number (RL).

Figure 11. The bogus data are in the 1100Z and 1130Z observations. This is a night summer situation with light to moderate winds. The winds and the surface temperatures correspond, but there is a variation in the temperature differences at upper levels.

Figure 12. This is a night spring situation, and in the bogus data there is approximately a 10-kt disparity between the actual wind and bogus winds.

Figure 13. This is a day summer situation and there is a disparity in the wind direction at all levels in the 1730Z bogus observation. But at 2030Z, the bogus observation is not much different from the 2000Z actual observation.

Figure 14. In this day winter situation, there is a good correspondence between the actual and bogus observations in both wind and temperature.

CONCLUSION

Actual Data Comparison

The rugged terrain at Towers 300 and 301 is a major factor in the low correlation of the U-Component for the towers. A contributing factor is the prevailing northerly wind component at the two towers.

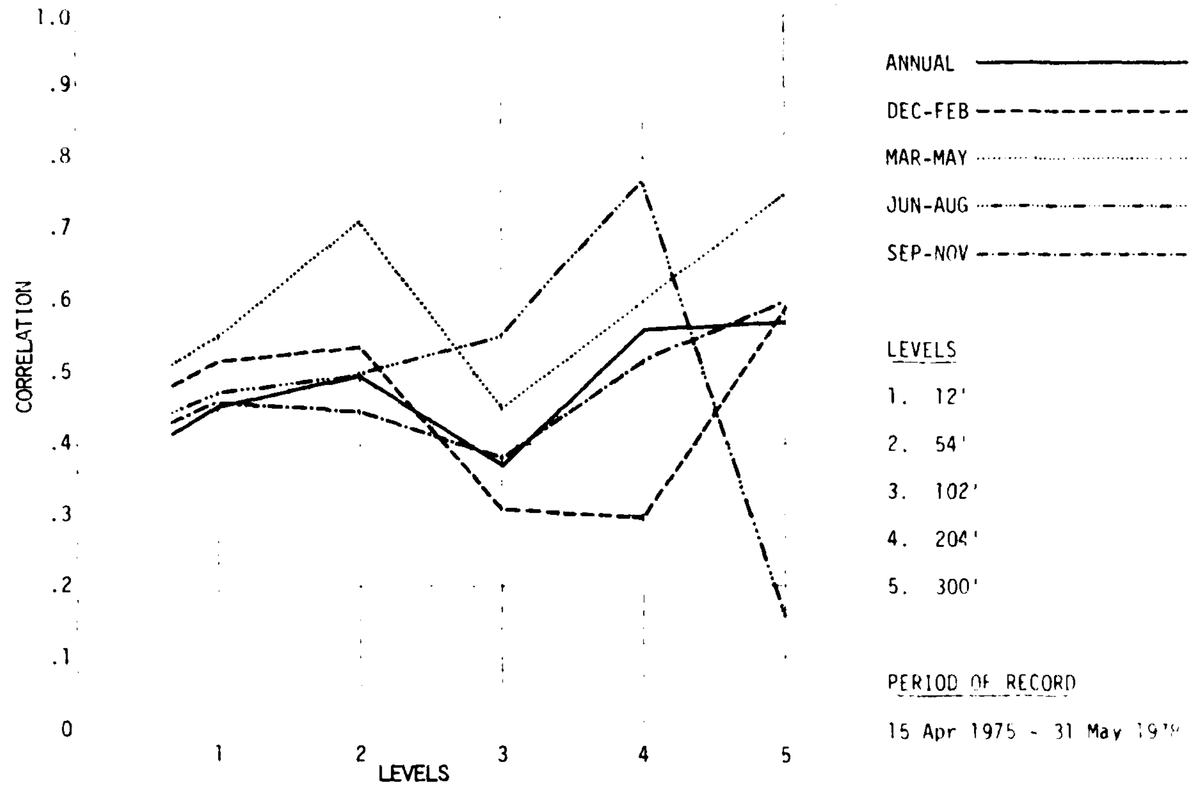

Figure 5. Correlation of U-Component (02-13Z) at Levels 1-5.

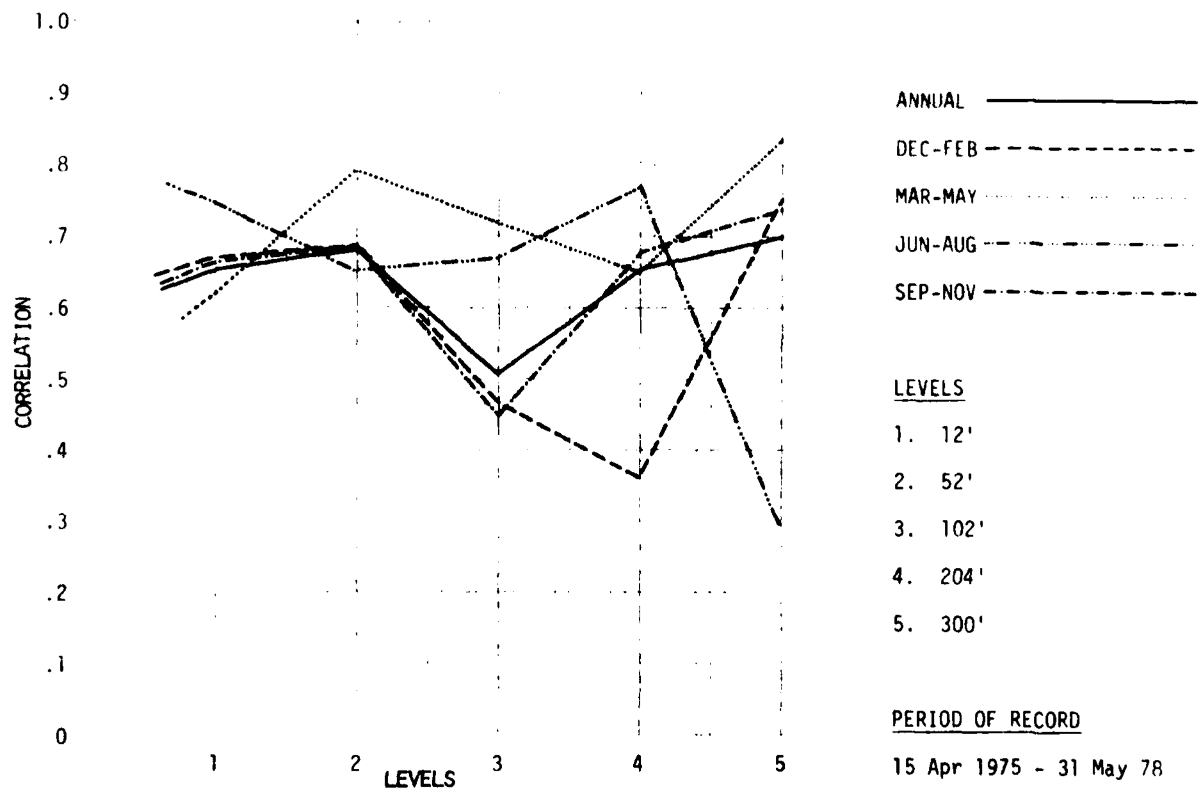

Figure 6. Correlation of U-Component (14-01Z) at Levels 1-5.

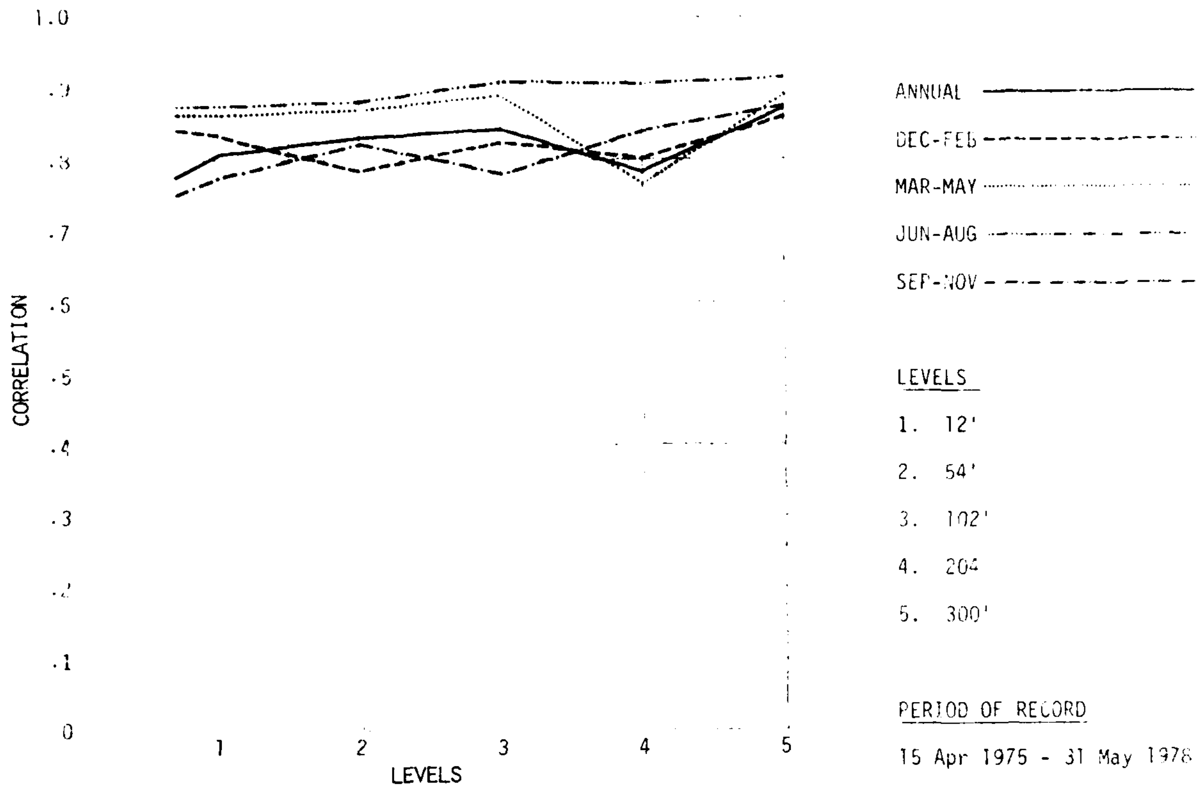

Figure 7. Correlation of V-Component (02-13Z) at Levels 1-5.

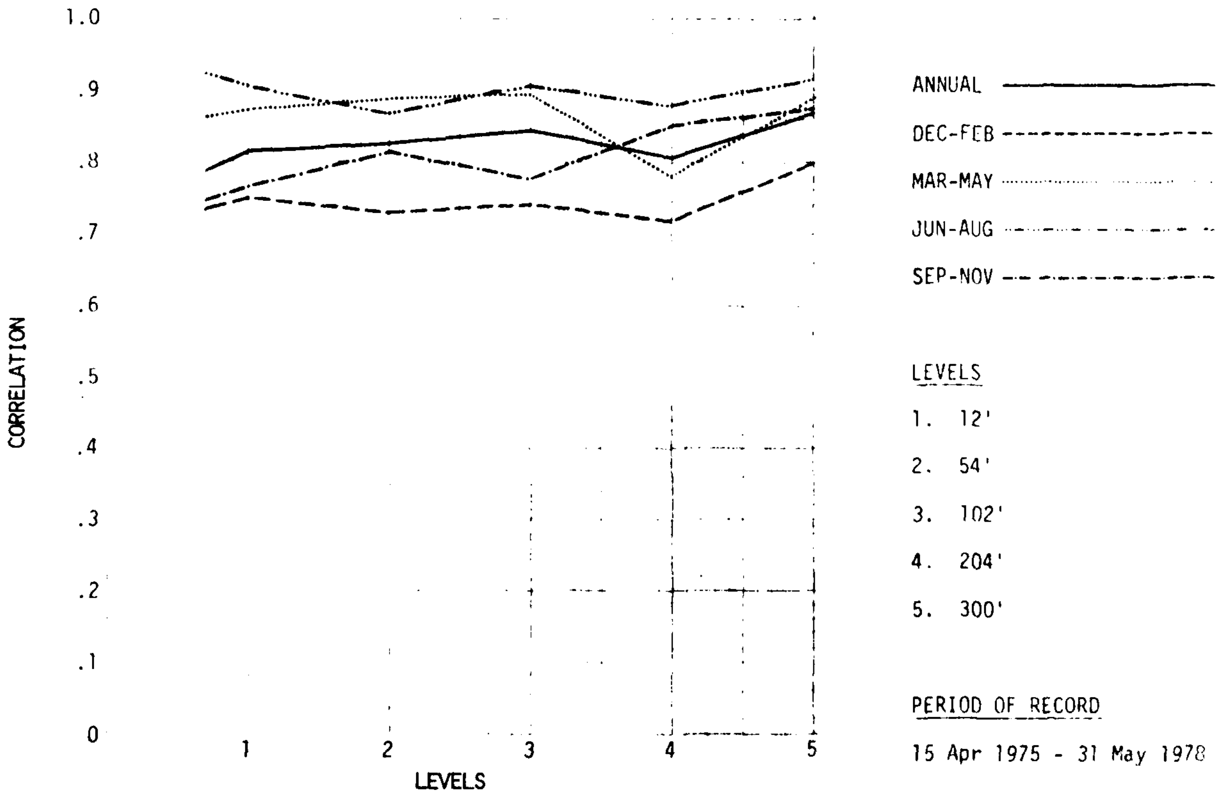

Figure 8. Correlation of V-Component (14-01Z) at Levels 1-5.

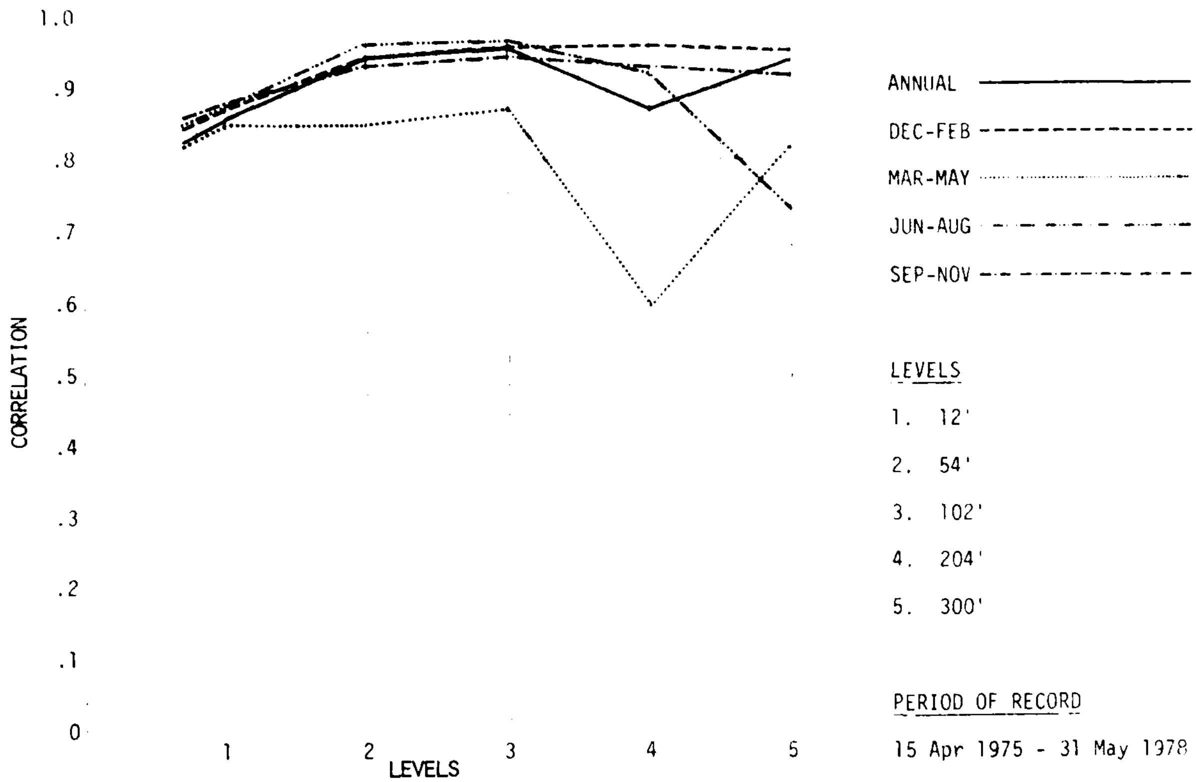

Figure 9. Correlation of Temperature (02-13Z) at Levels 1-5.

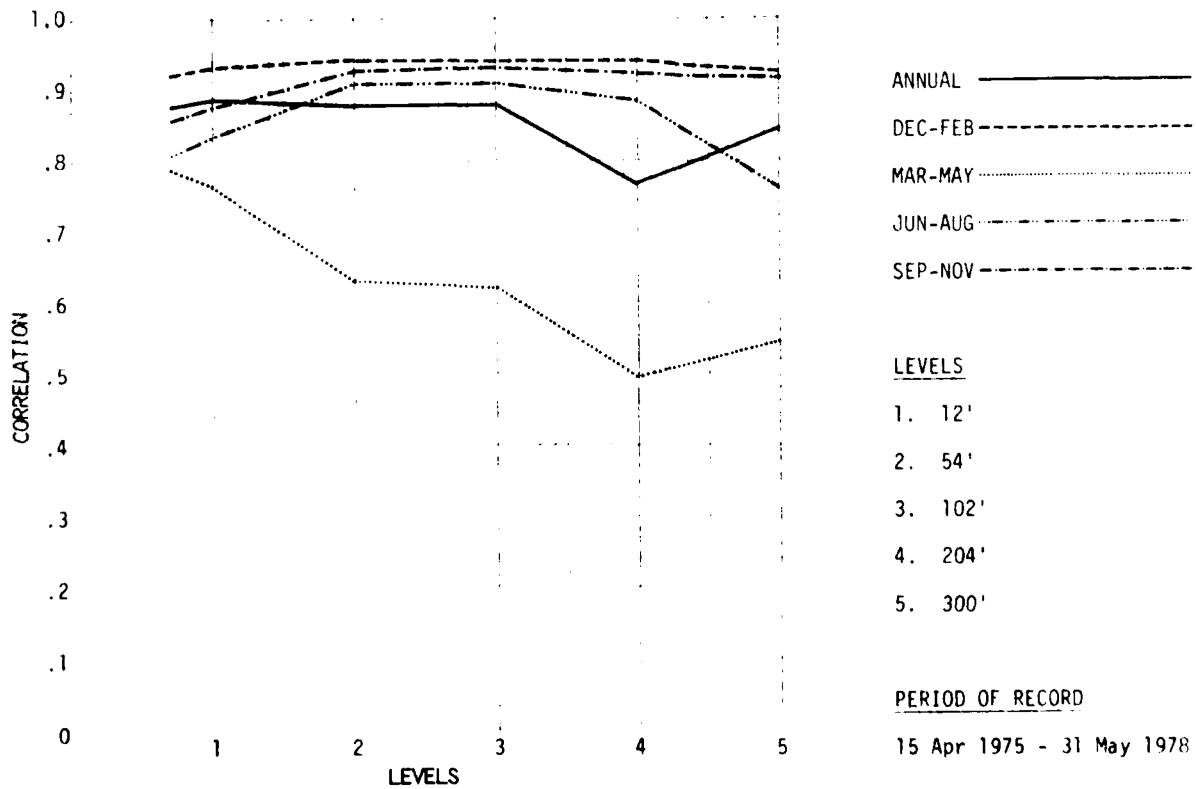

Figure 10. Correlation of Temperature (14-01Z) at Levels 1-5.

YYMMDD	HHMM	BLKSTN	TWR	IP	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	TMP	TD3	TD4	TD5	TD6	DD1	DD2	FL
76 725	200Z	723930	301	15	9	15	20	7	19	21	0	20	23	347	20	22	348	20	23	***	**	**	***	**	**	55	-7	-9	-2	-13	***	***	9
76 725	230Z	723930	301	15	11	14	21	10	18	20	0	19	22	349	19	22	346	20	23	***	**	**	***	**	**	55	-4	-6	0	-11	***	**	9
76 725	300Z	723930	301	15	18	16	24	16	19	23	0	20	25	350	21	25	345	22	25	***	**	**	***	**	**	54	-3	-5	2	-10	***	**	9
76 725	330Z	723930	301	15	9	14	18	9	18	21	0	19	22	348	20	23	348	20	23	***	**	**	***	**	**	54	-3	-4	2	-9	***	***	9
76 725	400Z	723930	301	15	7	15	20	6	18	20	0	19	20	346	19	21	349	20	22	***	**	**	***	**	**	55	-2	-2	3	-8	***	***	9
76 725	430Z	723930	301	15	15	13	21	14	16	23	0	18	23	351	19	23	347	20	24	***	**	**	***	**	**	54	-1	-3	2	-8	***	***	9
76 725	500Z	723930	301	15	15	14	21	13	17	21	0	18	21	349	18	20	347	19	21	***	**	**	***	**	**	54	-1	-1	4	-7	***	***	9
76 725	530Z	723930	301	15	9	13	18	8	16	20	0	17	20	349	18	20	345	19	21	***	**	**	***	**	**	54	0	-1	4	-7	***	***	9
76 725	600Z	723930	301	15	10	13	18	9	16	20	0	17	20	347	18	19	349	19	21	***	**	**	***	**	**	54	0	-1	4	-6	***	***	9
76 725	630Z	723930	301	15	12	12	19	10	15	20	0	17	21	348	18	21	349	19	22	***	**	**	***	**	**	54	0	-1	4	-6	***	**	9
76 725	700Z	723930	301	15	9	13	20	7	17	21	0	18	21	349	18	21	346	19	22	***	**	**	***	**	**	54	-1	-2	3	-8	***	***	9
76 725	730Z	723930	301	15	9	14	21	8	17	22	0	18	22	349	18	21	345	19	22	***	**	**	***	**	**	54	-2	-2	2	-8	***	***	9
76 725	800Z	723930	301	15	10	12	19	8	17	20	0	18	21	348	18	21	348	19	22	***	**	**	***	**	**	54	-2	-2	2	-8	***	***	9
76 725	830Z	723930	301	15	8	11	15	4	14	17	0	15	17	348	14	17	346	15	19	***	**	**	***	**	**	54	-1	-2	3	-8	***	***	9
76 725	900Z	723930	301	15	21	10	11	17	12	12	0	13	14	352	14	14	343	14	16	***	**	**	***	**	**	54	-1	-2	3	-8	***	***	9
76 725	930Z	723930	301	15	16	6	9	16	7	9	0	8	9	355	7	9	333	8	9	***	**	**	***	**	**	54	-1	-2	3	-7	***	***	9
76 725	1000Z	723930	301	15	17	5	8	13	6	8	0	7	8	347	7	9	350	7	9	***	**	**	***	**	**	54	-1	-1	2	-7	***	***	9
76 725	1030Z	723930	301	15	7	5	7	7	5	7	0	6	7	347	6	7	349	6	7	***	**	**	***	**	**	54	-1	-2	2	-8	***	***	9
76 725	1100Z	723930	301	**	21	5	**	7	6	**	353	7	**	349	7	**	350	6	**	***	**	**	***	**	**	53	7	4	47	9	***	***	**
76 725	1130Z	723930	301	**	21	5	**	8	6	**	352	7	**	349	7	**	343	6	**	***	**	**	***	**	**	53	8	5	41	9	***	***	**
76 725	1200Z	723930	301	15	25	5	7	22	6	9	0	7	8	350	7	8	344	7	8	***	**	**	***	**	**	54	-2	-2	2	-9	***	***	9
76 725	1230Z	723930	301	15	24	5	8	24	6	7	0	7	8	352	7	8	341	7	8	***	**	**	***	**	**	53	-2	-3	2	-8	***	***	9
76 725	1300Z	723930	301	15	24	5	7	30	6	8	0	7	8	351	7	8	340	7	8	***	**	**	***	**	**	53	-2	-2	2	-7	***	***	9
76 725	1330Z	723930	301	15	19	5	9	16	6	7	0	7	9	349	7	6	346	7	8	***	**	**	***	**	**	53	-3	-4	1	-9	***	***	9

JOB COMPLETED.   0 TAPE ERRORS   24 OBS EXTRACTED   44351 OBS READ.

Figure 11. Example of Summer Night Bogus Data.

YYMMDD	HHMM	BLKSTN	TWR	IP	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	TMP	T03	T04	T05	T06	DP1	P.	F.
76 318	200Z	723930	301	15	21	13	**	11	16	20	347	17	21	355	17	20	12	15	20	***	**	**	***	**	**	51	-5	-7	1	-13	***	***	[illegible]
76 318	230Z	723930	301	15	26	14	21	17	17	21	341	18	22	358	18	22	17	16	21	***	**	**	***	**	**	51	-3	-5	2	-12	***	***	9
76 318	300Z	723930	301	15	25	14	21	17	18	22	341	19	23	358	19	22	18	16	23	***	**	**	***	**	**	50	-3	-5	3	-11	***	***	[illegible]
76 318	330Z	723930	301	15	32	13	21	22	16	22	335	18	21	1	18	26	24	16	21	***	**	**	***	**	**	50	-1	-5	-5	-11	***	***	9
76 318	400Z	723930	301	15	38	13	19	30	15	21	328	17	24	4	19	25	30	17	25	***	**	**	***	**	**	50	5	0	5	-5	***	***	9
76 318	430Z	723930	301	15	45	13	23	36	16	23	325	18	26	6	20	26	31	19	28	***	**	**	***	**	**	51	7	7	17	4	***	***	[illegible]
76 318	500Z	723930	301	15	38	13	22	31	16	22	329	18	23	6	19	24	30	17	25	***	**	**	***	**	**	51	7	6	16	4	***	***	[illegible]
76 318	530Z	723930	301	15	34	13	20	25	16	20	336	17	21	2	16	23	19	15	24	***	**	**	***	**	**	52	5	5	15	1	***	***	[illegible]
76 318	600Z	723930	301	15	17	12	18	12	15	20	347	17	22	357	17	22	9	15	22	***	**	**	***	**	**	50	9	11	23	11	***	***	[illegible]
76 318	630Z	723930	301	15	27	12	17	20	15	18	338	16	18	359	17	21	10	15	23	***	**	**	***	**	**	48	3	4	14	4	***	***	9
76 318	700Z	723930	301	15	20	11	16	13	15	17	347	16	19	356	17	24	7	16	22	***	**	**	***	**	**	49	21	24	35	25	***	***	[illegible]
76 318	730Z	723930	301	15	20	12	18	13	16	21	347	17	22	354	19	22	6	18	24	***	**	**	***	**	**	49	10	12	13	9	***	***	9
76 318	800Z	723930	301	15	28	14	21	20	18	24	340	20	25	358	21	28	16	22	26	***	**	**	***	**	**	50	0	-1	8	-5	***	***	[illegible]
76 318	830Z	723930	301	15	28	15	22	19	19	25	341	21	26	357	22	26	16	22	26	***	**	**	***	**	**	51	0	-1	8	-5	***	***	[illegible]
76 318	900Z	723930	301	15	27	14	22	17	18	23	341	19	24	358	20	25	18	21	26	***	**	**	***	**	**	51	0	-1	6	-8	***	***	[illegible]
76 318	930Z	723930	301	15	34	14	22	26	17	23	332	19	25	4	20	26	27	20	25	***	**	**	***	**	**	51	0	-2	6	-9	***	***	[illegible]
76 318	1000Z	723930	301	15	34	14	20	27	17	21	332	19	26	4	21	25	28	19	26	***	**	**	***	**	**	51	0	-2	[illegible]	-7	***	***	9
76 318	1030Z	723930	301	15	36	13	22	27	16	23	332	18	25	4	20	23	24	19	24	***	**	**	***	**	**	50	0	-1	8	-4	***	***	9
76 318	1100Z	723930	301	**	32	7	**	37	8	**	18	6	**	7	8	**	18	15	**	***	**	**	***	**	**	50	3	5	19	10	***	***	**
76 318	1130Z	723930	301	**	23	6	**	27	9	**	10	9	**	360	10	**	14	15	**	***	**	**	***	**	**	50	1	2	18	6	***	***	[illegible]
76 318	1200Z	723930	301	15	29	15	23	21	19	24	358	19	25	1	20	24	19	20	24	***	**	**	***	**	**	51	1	[illegible]	7	-9	***	***	[illegible]
76 318	1230Z	723930	301	15	29	15	22	20	18	25	338	21	25	359	22	26	17	21	26	***	**	**	***	**	**	51	1	-2	6	-10	***	***	9
76 318	1300Z	723930	301	15	33	15	21	23	20	24	337	22	[illegible]	1	22	26	19	21	26	***	**	**	***	**	**	[illegible]	2	-1	5	-11	***	***	9
76 318	1330Z	723930	301	15	25	14	22	17	18	21	341	19	22	359	20	24	18	19	25	***	**	**	***	**	**	52	1	-1	3	-12	***	***	9

JOB COMPLETED.   0 TAPE ERRORS   24 OBS EXTRACTED   44351 OBS READ.

Figure 12. Example of Spring Night Bogus Data.

YYMMDD	HHMM	BLKSTN	TWR	IP	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	TMP	TD3	TD4	TD5	TD6	DP1	DP3	FC
76 730	1400Z	723930	301	15	337	2	3	336	2	3	328	2	3	325	2	3	343	2	3	***	**	**	***	**	**	56	-2	-5	9	-9	***	***	[illegible]
76 730	1430Z	723930	301	15	342	2	3	346	2	3	345	2	3	345	2	3	299	2	3	***	**	**	***	**	**	57	-2	-5	9	-6	***	***	[illegible]
76 730	1500Z	723930	301	15	339	3	**	341	3	4	337	3	4	340	2	5	287	2	**	***	**	**	***	**	**	57	-4	-5	10	-6	***	***	9
76 730	1700Z	723930	301	15	215	4	6	210	4	6	201	4	6	251	4	7	190	4	6	***	**	**	***	**	**	58	-8	-11	1	-16	***	***	7
76 730	1730Z	723930	301	**	351	1	**	311	1	**	291	2	**	311	2	**	256	1	**	***	**	**	***	**	**	58	-2	-13	18	-4	***	***	**
76 730	1800Z	723930	301	15	190	6	10	191	6	8	186	6	6	250	6	9	187	6	8	***	**	**	***	**	**	58	-9	-11	1	-12	***	***	[illegible]
76 730	1830Z	723930	301	15	188	5	8	188	5	7	186	6	7	253	6	8	191	6	9	***	**	**	***	**	**	58	-11	-14	-4	-18	***	***	6
76 730	1900Z	723930	301	15	210	4	8	209	5	7	201	5	6	253	5	7	197	5	7	***	**	**	***	**	**	59	-20	-23	-13	-27	***	***	9
76 730	1930Z	723930	301	15	237	4	7	233	5	6	222	5	7	257	5	6	214	5	8	***	**	**	***	**	**	61	-29	-25	-22	-32	***	***	[illegible]
76 730	2000Z	723930	301	15	234	4	8	227	5	7	215	5	8	256	5	7	220	4	7	***	**	**	***	**	**	61	-32	-22	-21	-31	***	***	9
76 730	2030Z	723930	301	**	237	1	**	234	2	**	250	2	**	254	3	**	233	4	**	***	**	**	***	**	**	60	-22	-26	-7	-29	***	***	**
76 730	2100Z	723930	301	**	215	2	**	235	3	**	251	2	**	250	3	**	243	4	**	***	**	**	***	**	**	62	-26	-39	-23	-46	***	***	**
76 730	2130Z	723930	301	**	214	2	**	225	3	**	241	3	**	240	3	**	230	4	**	***	**	**	***	**	**	63	-31	-43	-25	-50	***	***	**
76 730	2200Z	723930	301	**	193	2	**	227	4	**	235	3	**	239	4	**	233	5	**	***	**	**	***	**	**	64	-31	-45	-34	-56	***	***	**
76 730	2230Z	723930	301	**	253	3	**	258	6	**	268	4	**	266	7	**	263	8	**	***	**	**	***	**	**	64	-28	-45	-31	-59	***	***	**
76 730	2300Z	723930	301	**	239	4	**	246	6	**	252	5	**	255	7	**	251	8	**	***	**	**	***	**	**	64	-27	-41	-26	-55	***	***	**
76 730	2330Z	723930	301	**	234	2	**	249	5	**	258	5	**	258	6	**	[illegible]	7	**	***	**	**	***	**	**	64	-22	-39	-24	-50	***	***	**
76 731	000Z	723930	301	**	231	2	**	244	5	**	251	3	**	254	3	**	245	6	**	***	**	**	***	**	**	62	-17	-27	-14	-42	***	***	**
76 731	030Z	723930	301	**	337	1	**	275	4	**	290	4	**	283	5	**	274	5	**	***	**	**	***	**	**	61	-12	-23	-11	-38	***	***	**
76 731	100Z	723930	301	**	314	1	**	278	3	**	294	3	**	286	4	**	276	5	**	***	**	**	***	**	**	61	-12	-22	-13	-36	***	***	**
76 731	130Z	723930	301	**	356	1	**	289	3	**	302	3	**	295	4	**	284	4	**	***	**	**	***	**	**	61	-9	-20	-5	-31	***	***	**

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Figure 13. Example of Summer Day Bogus Data.

YYMMDD	HHMM	BLKSTN	TWR	IP	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	DIR	SP	GT	TMP	TD3	TD4	TD5	TD6	DP1	DP3	[illegible]
76 112	1400Z	723930	301	30	28	13	17	21	17	21	18	18	23	348	20	25	16	22	26	***	**	**	***	**	**	51	11	15	34	15	***	***	[illegible]
76 112	1430Z	723930	301	30	25	14	21	20	18	24	18	20	26	358	21	27	20	23	27	***	**	**	***	**	**	52	11	14	32	12	***	***	[illegible]
76 112	1500Z	723930	301	30	27	15	26	21	20	26	20	21	27	21	23	28	25	25	28	***	**	**	***	**	**	52	10	12	32	9	***	***	9
76 112	1530Z	723930	301	30	26	14	20	21	18	25	19	19	28	24	21	27	24	23	29	***	**	**	***	**	**	52	9	10	28	6	***	***	9
76 112	1600Z	723930	301	15	30	14	20	25	18	23	23	19	25	30	21	25	28	22	25	***	**	**	***	**	**	52	4	6	21	-1	***	***	9
76 112	1630Z	723930	301	15	19	11	18	13	15	20	12	16	21	17	18	23	17	20	23	***	**	**	***	**	**	52	-1	-4	16	-9	***	***	[illegible]
76 112	1700Z	723930	301	15	13	13	19	8	17	21	5	16	21	359	19	22	10	20	22	***	**	**	***	**	**	53	-8	-10	5	-17	***	***	9
76 112	1730Z	723930	301	15	11	13	20	6	17	22	3	18	22	349	19	22	9	19	23	***	**	**	***	**	**	53	-12	-16	-2	-25	***	***	[illegible]
76 112	1800Z	723930	301	15	6	13	20	0	18	23	359	18	22	329	19	24	6	19	24	***	**	**	***	**	**	54	-16	-20	-6	-31	***	***	9
76 112	1830Z	723930	301	15	8	13	20	0	17	21	358	18	22	321	19	22	360	20	23	***	**	**	***	**	**	55	-18	-23	-12	-37	***	***	9
76 112	2000Z	723930	301	**	1	14	**	348	17	**	359	18	**	338	19	**	351	22	**	***	**	**	***	**	**	56	-17	-35	12	-44	***	***	**
76 112	2030Z	723930	301	**	3	12	**	352	14	**	1	15	**	342	15	**	354	18	**	***	**	**	***	**	**	56	-18	-36	0	-42	***	***	**
76 112	2100Z	723930	301	**	3	12	**	352	15	**	2	16	**	343	16	**	353	19	**	***	**	**	***	**	**	56	-16	-39	9	-43	***	***	**
76 112	2230Z	723930	301	**	4	12	**	334	14	**	2	16	**	345	15	**	356	18	**	***	**	**	***	**	**	56	-12	-32	17	-38	***	***	**
76 112	2300Z	723930	301	**	4	13	**	353	[illegible]	**	1	17	**	344	17	**	355	20	**	***	**	**	***	**	**	56	-11	-26	20	-37	***	***	**
76 112	2330Z	723930	301	**	3	16	**	352	20	**	1	21	**	342	21	**	354	22	**	***	**	**	***	**	**	56	-7	-24	16	-36	***	***	**
76 113	0000Z	723930	301	**	3	15	**	351	19	**	359	19	**	341	20	**	354	23	**	***	**	**	***	**	**	54	-2	-18	28	-21	***	***	**
76 113	0030Z	723930	301	**	4	13	**	354	16	**	360	17	**	343	18	**	352	20	**	***	**	**	***	**	**	54	-1	-15	23	-21	***	***	**
76 113	0100Z	723930	301	**	4	15	**	358	17	**	359	18	**	348	19	**	360	21	**	***	**	**	***	**	**	53	3	-9	28	-6	***	***	**
76 113	0130Z	723930	301	**	4	15	**	359	16	**	359	18	**	345	19	**	1	21	**	***	**	**	***	**	**	52	5	-3	27	1	***	***	**

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Figure 14. Example of Winter Day Bogus Data.

Table 5. Comparisons of Correlation Coefficients for Towers 300 and 301.

Component	Level	Before Bogus 301(A)/300(A) 02-13Z	14-01Z	After Bogus 301(A)/301(B) 02-13Z	14-01Z
U	1	0.413	0.634	0.518	0.641
U	2	0.445	0.683	0.511	0.687
U	3	0.370	0.503	0.560	0.619
U	4	0.544	0.651	0.560	0.650
U	5	0.562	0.683	0.513	0.689
V	1	0.802	0.807	0.860	0.858
V	2	0.818	0.813	0.860	0.858
V	3	0.821	0.824	0.862	0.858
V	4	0.781	0.806	0.829	0.860
V	5	0.859	0.862	0.868	0.862
T	1	0.859	0.888	0.925	0.885
T	2	0.946	0.871	0.947	0.866
T	3	0.950	0.873	0.950	0.871
T	4	0.849	0.767	0.933	0.871
T	5	0.923	0.837	0.925	0.854

A = Actual Data
B = Bogus Data

CONCLUSION

Actual Data Comparison

The rugged terrain at Towers 300 and 301 is a major factor in the low correlation of the U-Component for the towers. A contributing factor is the prevailing northerly wind component at the two towers.

For each component there is variance in the level comparisons. Again, the terrain probably causes most of variances. The best correlations between the two towers occur in the summer for all three components.

Bogus Data Comparisons

The regression equations used did not significantly improve the correlation coefficants for bogus Tower 301(A)/301(B) over the coefficants between Towers 300 and 301. The examples in Table 5 show that for some levels the bogus values correspond with the actual values. No increase in accuracy would be achieved using the bogus procedure to expand the POR of Tower 301. The actual Tower 300 data would produce comparable results.

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Appendix A

REGRESSION TECHNIQUE

This appendix presents the mathematical equations that are used by program ENBWTREM to select the independent variables and obtain their regression coefficients. The procedure, which comes from the IBM System 360 Scientific Subroutine Package, Version III, starts with the sums of cross-products of deviations matrix. The derivation of this matrix is not covered here; for information on its derivation, refer to other sources on regression analysis.

In each step of the regression

$$i = 1, 2, \ldots, q$$

where q = number of independent variables

The first step in selecting the independent variable entering the regression is to compute the amount of reduction of sum of squares for each variable by

$$C_j = \frac{a_{jy}^2}{a_{jj}} \tag{A-1}$$

where

C_j = reduction of sum of squares,

a_{jj} = an element in the sum of cross-products of deviations matrix which will be modified in successive steps,

$j = 1, 2, \ldots, q$ are *independent variables* ($j \neq$ *variables deleted* and variables entered before the i^{th} step),

y = dependent variable.

The second step is to find the maximum (over j) of C.

Set $S_i = C_j$ to indicate the sum of squares that will be reduced in the i^{th} step. The proportion of S_i to the total is obtained by

$$P = \frac{S_i}{D} \tag{A-2}$$

where $$D = \sum_{j=1}^{n} (y_j - \bar{y})^2$$

n = number of observations.

The cumulative sum of squares reduced is obtained by

$$S_{cum} = S_{cum} + S_i \tag{A-3}$$

and the cumulative proportion reduced by

$$P_{cum} = P_{cum} + P \tag{A-4}$$

The multiple correlation coefficient is computed by

$$R = (P_{cum})^{1/2} \tag{A-5}$$

and adjusted for degrees of freedom by

$$R_c = [1-(1-R^2)\ (n-1)/(n-k)]^{1/2}$$

where k = independent variables in the regression.

The F-value for analysis of variance is given by

$$F = \frac{S_{cum}/k}{(D-S_{cum})/(n-k-1)}$$

The standard error of the estimated y is obtained by the use of the formula

$$s_{y.12...i} = \left(\frac{D-S_{cum}}{n-k-1}\right)^{1/2} \qquad (A-7)$$

and adjusted by

$$s_c = s\,[(n-1)/(n-k)]^{1/2}$$

Then, the following is computed

$$a_{jj} = a_{jj} + \frac{a_{ij}^2}{a_{ii}} \qquad (A-[illegible])$$

where i = variable entered in the i^{th} step,

$j = v_1, v_2, \ldots, v_{i-1}$ are the variables entered in the regression before the i^{th} step, and

$$g_{ik} = \frac{a_{ik}}{a_{ii}} \qquad (A-[illegible])$$

where $k = 1, 2, \ldots, m$ *are variables* including y ($k \neq$ variables deleted and the variables entered in the i^{th} step).

Regression coefficients are computed by:

$$b_i = g_{iy}$$

$$b_{i-1} = g_{(i-1)y} - b_i g_{(i-1)i} \qquad (A-10)$$

$$b_{i-2} = g_{(i-2)y} - b_i g_{(i-2)i} - b_{i-1} g_{(i-2)(i-1)}$$

etc.,

and the value of the intercept is

$$b_o = \bar{y} - \sum_{j=1}^{k} b_j \bar{x}_j \qquad (A-11)$$

where k = number of independent variables in the regression.

Standard error of regression coefficients are given by

$$s_{bj} = (a_{jj} s_{y.12...i})^{1/2} \qquad (A-12)$$

where $j = v_1, v_2, \ldots, v_i$ are variables in the regression, and t-values as

$$t_j = \frac{b_j}{s_{bj}} \qquad (A-13)$$

Perform the reduction to eliminate the variable entered in the i^{th} step,

$$a_{jk} = a_{jk} - a_{ji} g_{ik} \qquad (A-14)$$

where i = variable entered in the i^{th} step,

$j = 1, 2, \ldots, m$ ($j \neq$ variables deleted or variables in the regression)

$k = 1, 2, \ldots, m$ ($k \neq$ variables deleted and the variable entered in the i^{th} step)

$$a_{ji} = \frac{a_{ji}}{-a_{ii}} \qquad \text{(A-1[illegible])}$$

$$a_{ii} = \frac{1}{a_{ii}} \qquad \text{(A-1[illegible])}$$

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